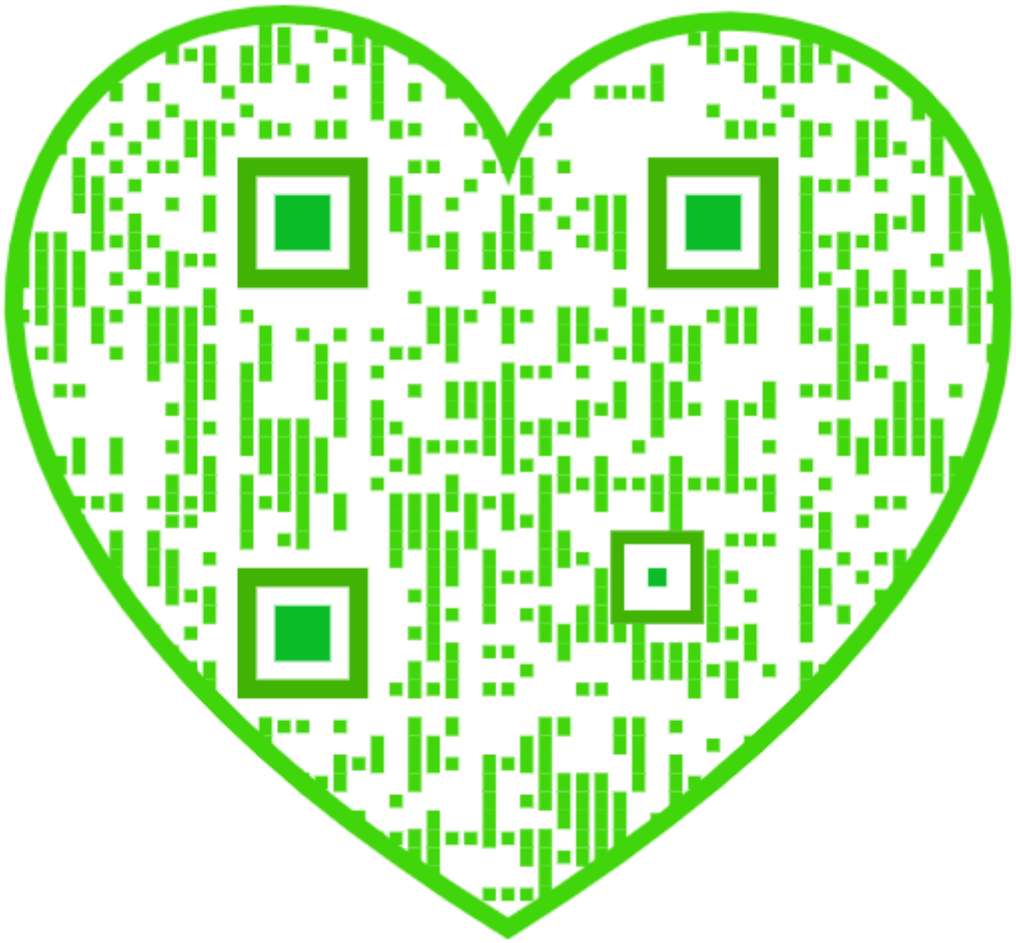

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L. O. HOWARD, Chief

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THE SWEET-POTATO LEAF-FOLDER.

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[With a complementary report regarding spraying experiments for its control, conducted in southern Texas by M. M. High.]

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INTRODUCTION.

The larva of *Pilocrocis tripunctata* Fab. (fig. 1 *c*, *d*), a member of the lepidopterous family Pyralidæ, was noted first as an enemy of sweet potatoes in Louisiana by the writer while cooperating with the Louisiana Experiment Stations in the fall of 1914. Since that time the species has been kept under observation at Baton Rouge, La., and has been noted also in Plaquemines and Tangipahoa Parishes.

The species, which may be called the "sweet-potato leaf folder" because of the habits of the larva, has not been observed as yet in destructive numbers in Louisiana; but it has been reported by Mr. M. M. High, of the Bureau of Entomology, as very injurious to the sweet potato near Brownsville, Tex., where he conducted control experiments with poisons during the fall of 1916. As it is possible that this pest may become an important enemy of sweet potatoes in the Southern States, it seems advisable to publish the results concerning its biology and the results of Mr. High's control experiments.[2]

[1] The author wishes to acknowledge the issistance of C. E. Smith and J. L. E. Lauderdale in the studies on the history and habits.

[2] Besides the complementary report by Mr. High, this bulletin includes notes made by him regarding the life history, habits, and enemies of the species in southern Texas. Especially because development under conditions existing in southern Texas may differ from that under conditions at Baton Rouge, statements taken from Mr. High's notes are credited to him. All other observations were made at Baton Rogue.

HISTORY, DISTRIBUTION, AND SYNONYMY.

The only published record regarding injury by this species appeared in 1915, when the writer mentioned the occurrence of the larva on sweet potato in Porto Rico (6).[1] It was described first as

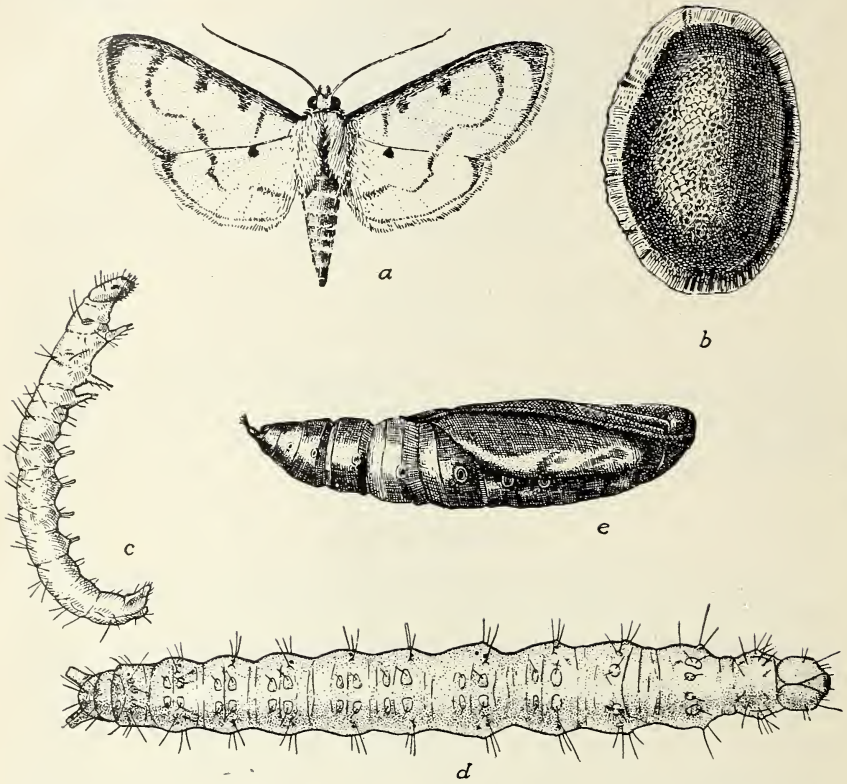

FIG. 1.—The sweet-potato leaf-folder (*Pilocrocis tripunctata*): *a*, Moth; *b*, egg; *c*, early stage of larva, from side; *d*, ventral view of larva; *e*, side view of pupa. All enlarged; *b*, highly magnified. (Original.)

Phalaena tripunctata by Fabricius in 1794 from material from the Central American Islands (1). Guénée recorded it (as *Botys cubanalis* Gn.) from Cuba (2), and Dyar listed it from Florida, Texas, and the West Indies (5).

Specimens from the following-named localities and now in the National Museum have been identified by Mr. August Busck: Kerville, Victoria, and San Antonio, Tex.; Mexico; Costa Rica; Jamaica, Cuba, and Grenada, West Indies. The addition of Baton Rouge, La., and Brownsville, Tex., completes the list of known localities where the species occurs.

[1] Figures in parentheses refer to "Literature cited," p. 12.

The following synonymy is recorded:

Phalaena tripunctata Fabr. 1794.
Botys cubanalis Guén. 1854.
Botys memmialis (F.) Walker. 1859.
Pilocrocis tripunctata Fabr. (Hampson). 1898.

DESCRIPTION OF STAGES.

THE EGG.

(Fig. 1, *b*.)

Thin, scalelike, with delicate walls, reticulated on upper surface; more or less regularly elliptical in outline, especially when laid singly. Being very plastic, the eggs vary considerably in shape. When laid the egg is at first colorless, practically transparent, and later the developing embryo can be seen plainly within. Measurements of 10 eggs that had been deposited singly: Average length, 1.06 mm., average width, 0.79 mm.

THE FIRST LARVA STAGE.

Of a number of larvæ examined, none of which was more than 24 hours old, the smallest measured about 1.5 mm. in length. The width of the head shield of all these individuals was very constant, about 0.25 mm.

Newly hatched larvæ are opaque, colorless, except for the dark, reddish-brown ocelli and the mouth parts, which are tinged faintly with brown. The body is cylindrical in shape, the surface smooth, glistening, with the setæ arising from colorless tubercles. In these newly hatched larvæ the head and legs are comparatively large, noticeably out of proportion to the rest of the body. After emergence from the eggs, however, the larvæ begin to increase rapidly in size, and this lack of proportion is soon lost. When the larvæ begin to feed the chlorophyll taken into their bodies imparts to them a greenish tinge.

LATER LARVA STAGES.

(Fig. 1, *c*, *d*; fig. 2, *a*, *b*.)

During the succeeding instars the shape of the larva remains cylindrical, the surface smooth and glistening. *In the third and subsequent instars tubercle ii of segments 3 and 4*[1] *is usually conspicuous because of its brownish or blackish color.* Sometimes, however, especially on segment 4, the tubercle is not dark.

When at rest the full-grown larva measures, immediately after feeding, about 27 mm. in length and 5 mm. in width. Measurements of the width of the head shields of 10 individuals gave an average of 1.81 mm., ranging from 1.75 mm. to 1.88 mm. The general color of the larva is bluish green. The head (fig. 4) is pale yellow, and the ocelli, tips of the antennæ, mouth parts, and claws of the true legs are brown.

THE PUPA.

(Fig. 1, *c*; fig. 2, *c*.)

The pupa is dark brown in color, somewhat lighter toward the posterior end. The surface is smooth, that of the abdominal segments dull and the remainder glistening. Eight bristles, curled at their tips, occur at the end of the cremaster.

Five pupæ averaged 15 mm. in length and 4 mm. in width at the widest point.

[1] The head is considered as segment 1, the prothorax as segment 2, and the others in succession.

THE ADULT.

(Fig. 1, *a*; fig. 3.)

The general color of the upper surface of the body and wings of the moth is light yellow, the wings iridescent. A dark grayish-brown band begins at the humeral angle of the forewing, from which it extends to the eye, and continues along the costal and outer margins of this wing and the outer margin of the hind wing. On either wing this band is widest at the apex. Inside the band and about one-sixteenth of an inch from it a wavy line of the same color

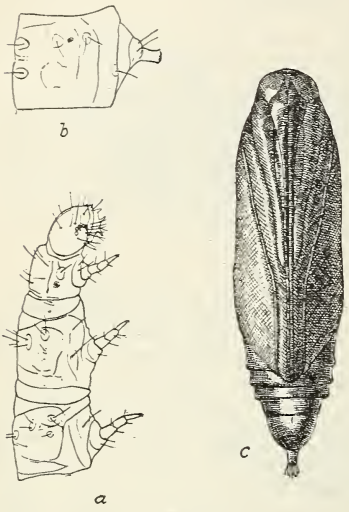

FIG. 2.—The sweetpotato leaf-folder: *a*, First three joints of larva, showing legs and arrangement of spiracles and spiracular tubercles; *b*, lateral view of a ventral segment; *c*, pupa, ventral view. All greatly enlarged. (Original.)

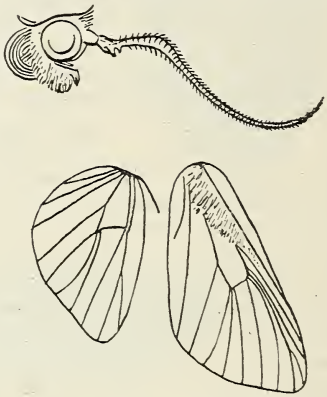

FIG. 3.—Wing venation and lateral view of head and antenna of a related species, *Pilocrocis ramentalis*, to show characters of genus. (Hampson.)

crosses both wings. Two black spots occur on the forewing, near the costal margin. The outer and larger one is near the middle of the margin and the smaller one about halfway between this and the base of the wing. A short, wavy, dark grayish-brown line occurs just inside this small black spot, extending backward from the band on the costal margin to a point about halfway across the wing. There is also a small black spot on the hind wing, near the costal margin and about halfway between the base of the wing and the wavy line previously noted. The markings are shown in figure 1, *a*.

The underside of the wings is lighter in color than are above, but have the same iridescent reflection with indications of the markings of the upper surface.

The ventral surface of the thorax and abdomen is white. The antennæ are light yellowish brown, and the legs white, except that the anterior surfaces of the first pair are for the most part of a dark grayish brown.

In the male the abdomen tapers more gradually to the posterior end than is the case in the female. The upper surface of the thorax also presents a more hairy appearance in the male, owing to the longer hairs of the tegulæ or lappets. With a lens a third point of difference is seen in the short bristles present on the underside of the basal portion of the antennæ of the male. These do not occur on the antennæ of the female.

Measurements of the wing expanse of 11 reared females gave an average of 27 mm., ranging from 25 mm. to 29 mm. The wing expanse of 7 reared males ranged from 25 mm. to 27 mm.

FOOD PLANTS.

In addition to the sweet potato as a food plant, moths have been reared from larvæ found feeding on uncultivated plants of the genus Ipomoea, to which the sweet potato belongs. It seems probable that some species of this genus, known under the common names of "bindweed," "wild sweet potato," and "wild morning-glory," are the natural larval food plants, and that the larvæ will feed on any of the numerous species of Ipomoea, in which genus are included a number of ornamental vines.

SEASONAL HISTORY AND HABITS.

OVIPOSITION.

Eggs have not been observed in the field at Baton Rouge, but the females, after feeding from pieces of sponge moistened in sweetened water, oviposited freely on sweet-potato plants in cages.

The eggs, which are securely fastened to the leaf, were placed on the underside, the areas alongside the leaf veins being a favorite location; Mr. High, however, from observations made in Texas, noted that apparently the eggs are deposited indiscriminately on either side of the leaf. Eggs are sometimes placed singly but as many as five have been noted in a group, their edges overlapping, although in no regular arrangement.

INCUBATION.

Eggs laid in the insectary at Baton Rouge on July 29 and 30 hatched on August 2 and 3, respectively. The period of incubation was, therefore, under these conditions, four days. The averages of the daily maximum and minimum temperatures for the insectary from July 29 to August 3, inclusive, were 92.5° and 74.0° F.

HABITS OF THE LARVA.

In the field the larvæ are found between separate leaves or portions of the same leaf which have been fastened together to form "shelters," each of which usually protects one larva. The larva constructs its shelter by spinning threads of silk from side to side across a portion of a leaf near the edge, each strand being shortened as the preceding strands contract in drying, until finally the edge of the leaf is

drawn completely over and fastened down with the shorter bands of silk. The precise process of this species has not been noted in detail. Mr. High has found that the larva when young eats small irregular holes in the leaf, but later consumes more of the leaf as the larva increases in size, in extreme cases devouring all of the leaf except the larger veins and midrib. The shelters and the injury to the leaves, due to the feeding of the larvæ, are shown in figure 4.

FIG. 4.—Sweet-potato vine showing work of sweet-potato leaf-folder. (Original.)

When the shelters are broken open and the larvæ disturbed they throw themselves rapidly about, much as a fish does when removed from water, and this violent action soon results in their reaching the surface of the soil, where, if there is a heavy growth of vines, they are difficult to find.

LENGTH OF LARVA STAGES.

The number of molts the larvæ undergo may vary, but the usual number apparently is 6. In the insectary at Baton Rouge during 1916 2 lots of adults were reared from eggs that had been laid by

moths kept in confinement. The first lot were from larvæ that issued on June 21. Eight of these spent 13 days in the larva stages, and 2 pupated 14 days after issuing from the egg. The averages of the daily maximum and minimum temperatures for this period, taken from a self-registering thermograph, were 95.3° and 72.6° F., respectively.

The second lot of larvæ were reared during August. They issued on August 3. Two pupated 13 days after issuing from the egg, while two required 14 days, one 15 days, and six 16 days for the larva stages. For this period the average of the daily maximum temperatures was 90° F. and the average of the daily minimum temperatures 72.8° F.

In the case of the larvæ reared during August observations were made to determine the length of time required for the various instars. Because of the fact that after the first five molts the larva usually devours all of the cast skins, with the exception of the tougher portion from the head, it is rather difficult to determine the exact time of molting, especially in the early stages. The time spent in each of the 6 instars was, however, ascertained from 7 larvæ. With two exceptions the periods were as follows: First instar, 3 days; 2d, 3d, 4th, and 5th instars, 2 days each; 6th instar, 5 days. One larva spent 3 days in the second instar and another only 4 days in the sixth instar.

PREPARATION FOR PUPATION.

After completing its growth the larva ceases feeding and constructs a cocoon, within which it transforms later to the pupa. During the period intervening between the time when the last food is taken and the time of pupation the larva undergoes a gradual change; it becomes shorter, the bluish-green color disappears, and the larva becomes sluggish.

In the insectary during July and August the time required in preparation for pupation was, with few exceptions, two days. In a few cases three days were required. Under the heading "Hibernation" the length of time passed in preparation for pupation by individuals that complete their larval growth later in the season is given.

PUPATION.

In the field and in the insectary pupæ normally are found in loose cocoons within the shelters made by the larvae. Larvae developing after the latter part of August sometimes construct in confinement a somewhat different type of cocoon, which will be discussed later.

The pupa period occupied from 6 to 9 days in the insectary during July and August. During September, 1915, two individuals

kept outdoors in glass jars transformed to moths 7 days after becoming pupæ.

HIBERNATION.

This species, judging by analogy, passes the winter months as a larva. The behavior of individuals kept in the insectary, however, should be mentioned in this connection. Larvæ collected in the field August 23, October 16, and November 1, 1915, the last date being the latest when larvæ were taken outdoors in 1915, were placed in the insectary. Here they constructed above the surface of the soil rather tough, brownish, silken cocoons of a more substantial nature than those from which moths issued during the summer months. Examination of some of these cocoons, made as late as December 11, showed that they contained inactive larvæ. The exact date when pupæ were formed was not ascertained, but moths began to issue as early as May 10. From observation it would appear that eggs are first deposited outdoors about this time.

On October 10, 1916, larvæ were found, in cocoons similar to those mentioned above, in a field of sweet potatoes at Baton Rouge. These cocoons were found at the surface of the soil, in portions of old, dead, sweet-potato leaves.

In southern Texas, according to Mr. High, the last generation doubtless passes the winter in the last larva instar and pupates in the spring or late in the winter. He has observed that the mature larva of this generation spins a cocoon of strong silk during the first half of November and remains in a quiescent state until ready to pupate. The cocoons usually are covered with soil or leaves, although any material the larva is able to draw together may be utilized. Where no such material is available it will make the cocoon entirely of silk.

THE LIFE CYCLE.

The minimum time required for the various stages in the insectary at Baton Rouge was as follows:

	Days.
Egg stage	4
Larva stages	13
Prepupa stage	2
Pupa stage	6
Total life cycle	25

In June larvæ were found in a cage 7 days after newly emerged moths had been placed therein, so that it appears that moths may begin egg-laying within at least 3 days after they have issued. This would give a minimum total of 26 days for the life cycle.

Under normal outdoor conditions the time necessary for the life cycle probably would be somewhat longer than that required in the

insectary, since the temperature of the insectary is higher than the outdoor temperature. In outdoor cages moths began to issue on August 24 and August 26, 28 and 29 days after the eggs had been deposited.

It appears that during the summer months the life cycle requires about five weeks in the field at Baton Rouge. Early in September, moths, pupæ, and larvæ in all stages of development were found on sweet-potato vines. There are probably four, and possibly five, generations during the season in the latitude of Baton Rouge.

NATURAL ENEMIES.

A tachina fly (*Exorista pyste* Walk.) and an ichneumon fly which Mr. A. B. Gahan, of the Bureau of Entomology, has pronounced to be a new species of the genus Bassus, have been reared from collections of larvæ made in the field at Baton Rouge, indicating that they are parasites of the sweet-potato leaf-folder. Adults of the spined soldier bug (*Podisus maculiventris* Say) have been observed with larvæ impaled on their beaks.

Mr. High observed a predacious enemy of the larva in the "jackdaw," or boat-tailed grackle (*Megaquiscalus major macrourus* Swainson). The following notes are from his records.

"This bird winters in southern Texas by millions and feeds on a number of insects that attack truck crops and particularly on larvæ. * * * observed it first feeding on the cabbage looper (*Autographa brassicæ* Riley) in 1913, two days after cabbage had been sprayed with an arsenical.

"Some species of larvæ after being poisoned have a habit of crawling to the top leaves of the plant upon which they are feeding before dying, and here they fall easy prey to the grackle. The poison apparently does not seriously affect the birds, since none have been found dead in the vicinity of sprayed crops."

THE SWEET-POTATO LEAF-FOLDER IN SOUTHERN TEXAS.[1]

The sweet-potato leaf-folder (*Pilocrocis tripunctata* Fab.) was first observed by the writer in southern Texas September 17, 1916, when larvæ were found sparingly on a plat of sweet potato at Brownsville, Tex. On September 29 the larvæ were observed at work in another field near Brownsville, and by this time were more numerous in the plat where first they were found. At this time a sudden change in the weather accompanied by hard showers somewhat reduced their numbers.

By the middle of October the caterpillars had become so abundant that it was found advisable to spray immediately. Later a

[1] Reported by M. M. High, Entomological Assistant, Bureau of Entomology, United States Department of Agriculture.

second application was made. The results of these treatments are recorded in this report.

SPRAYING EXPERIMENTS.

On October 19 some sweet potatoes at Brownsville were sprayed for the sweet-potato leaf-folder with arsenate of lead at the rate of 1 pound (powder) to 50 gallons of water. At the time the spray was applied the infestation was localized in spots, mainly on one side of the plat. On the following night a shower washed a considerable amount of the poison from the vines. An examination October 22 showed that somewhat more than one-half of the larvæ were still feeding actively and did not appear to be poisoned. By October 25 the living larvæ had decreased to about 25 per cent of the original number, though it appeared that birds were partially responsible for the decrease.

Afterwards few larvæ were found up to the first few days of November, when they reappeared in large numbers and dozens could be collected in a very small space.

November 9 the sweet-potato patch was divided into three plats and sprayed with lead arsenate and zinc arsenite at different strengths. On account of the matting of the vines it was impossible to ascertain the number of larvæ by count on any one plant, so that the number was estimated over a given space both before and after spraying.

Plat No. 1 was sprayed with lead arsenate: 2 pounds (powder) to 50 gallons of water. The powder was first converted to paste and the remainder of the water was added. The spray was applied early in the afternoon, when the foliage was perfectly dry and a fairly uniform coating was secured. Particular care was taken to coat at least one side of the foliage thoroughly.

Plat No. 2 was sprayed immediately with lead arsenate at the rate of 1 pound (powder) to 50 gallons of water. This was applied in the same manner as in plat No. 1, but the spray seemed to spread more uniformly over the leaves than did the heavier dosage.

Plat No. 3 was sprayed with zinc arsenite: 1 pound (powder) to 40 gallons of water in which 12 pounds of cactus, to increase adhesiveness, had been placed 20 hours before. The solid cactus detritus was thrown out and the zinc arsenite added. This spray adhered better to the foliage than did either of the other sprays, though the whitening of the foliage was less definite than in plat No. 1, and hardly as much so as in plat No. 2.

On November 11 an examination showed that in plat No. 1 the leaves of the potato were scorched slightly, although not enough to cause serious damage. It was estimated that about 94 per cent of the larvæ had been destroyed or were past feeding. In plat No. 2

the mortality ranged from 93 to 95 per cent; in plat No. 3 mortality was a fraction higher, about 95 to 96 per cent.

All the plats were sprayed with a hand sprayer holding about 5 gallons of spray mixture, and probably a little more thoroughly than would be done on a large scale by inexperienced help. When potatoes are planted on soils with high nitrogen content, the foliage is usually heavy, requiring careful manipulation to secure thorough distribution of the spray mixture.

SUMMARY OF SPRAYING EXPERIMENTS.

The foregoing experiments demonstrate that the larvæ of the sweet-potato leaf-folder (*Pilocrocis tripunctata* Fab.) can be killed readily by timely applications of arsenical sprays. Either arsenate of lead or zinc arsenite at the rate of 1 or 2 pounds (powder) to 50 gallons of water will give favorable results. If the spraying is done early, one application may be sufficient, whereas if treatment is delayed until a large number of larvæ have spun cocoons, two or more applications may be necessary in order to effect complete control.

SUMMARY.

The caterpillar of a pyralid moth (*Pilocrocis tripunctata* Fab.) was very injurious to the foliage of sweet potato in southern Texas during the fall of 1916. No previous instance of injury appears to be recorded although the insect has long been known to inhabit the Gulf region. It occurs also in the West Indies and has been mentioned as feeding on the sweet potato in Porto Rico.

The various stages of this insect, which, because of the habits of the larva, has been given the name of "the sweet-potato leaf-folder," have been described from life-history studies carried on at Baton Rouge, La.

The minimum length of time required for the life cycle in the insectary at Baton Rouge, La., was found to be about 26 days. In the field there are probably 4, and possibly 5, generations a year in the latitude of Baton Rouge. The winter months apparently are spent in the last larva stage within a cocoon at or near the surface of the soil.

Two parasitic flies have been reared from the larvæ, and the spined soldier-bug has been found to be predacious upon the larvæ. In Texas the "jackdaw" or boat-tailed grackle feeds upon them.

Experiments conducted by the Bureau of Entomology indicate that the larvæ can be killed readily by spraying the foliage with either arsenate of lead or arsenite of zinc at the rate of 1 or 2 pounds (powder) to 50 gallons of water.

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Mention of injury to sweet-potato leaves by larvæ. Original figure of adult.

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